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Office for Information Technology Policy

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ALA American Library Association

May 2, 1997

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Federal Communications Commission
Office of Secretary

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, NW Room 222
Washington, DC 20554

Re: Ex Parte Presentation
CC Docket No: 96-45, Federal-State Joint Board on Universal Service

Dear Mr. Caton:

In response to questions from Irene Flannery of the FCC staff, Andrew Magpantay of the American Library Association faxed copies of the two attached articles to Ms. Flannery on May 1, 1997. They deal with the issue of determining what the appropriate measure of poverty for libraries should be for determining discounts under CC 96-45.

If you have any questions on this filing, please contact me at 202/628 8421.

Sincerely,

Andrew Magpantay
Director
Office for Information Technology Policy
American Library Association

Enclosure

CC:

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Geographic Information Systems and Libraries:

Patrons, Maps, and Spatial Information

Papers Presented at the
1995 Clinic on Library Applications of Data Processing
April 10-12, 1995
Graduate School of Library and Information Science
University of Illinois at Urbana-Champaign

CHRISTIE KOONTZ

Using Geographic Information Systems for Estimating and Profiling Geographic Library Market Areas

A definition of legal service or market area is difficult for public library management due to limited available data regarding user residence, and because people may cross service lines for any number of reasons. Yet an accurate estimate and a subsequent socioeconomic profile of the geographic market to be served (market analysis) is essential in order to provide unique community-based services and materials. Geographic information system (GIS) software can facilitate library market analysis by graphically estimating geographic boundaries and analyzing socioeconomic characteristics within prescribed markets in one online environment. This discussion illustrates the utility of GIS in estimating and profiling library markets. The Evansville-Vanderburgh County public library system is used to provide realistic library market analysis situations.

INTRODUCTION

A definition of legal service or market area[1] is difficult and complex for public library management to establish for two major reasons: (1) library managers may not know where the majority of users reside due to limited knowledge and data collection, and (2) because people may cross service lines for any number of reasons (Van House et al., 1987). Historically, the library profession develops market areas from the "inside-out" and the "outside-in." The "inside-out" approach would be quantitative standards mandating a one mile service area (Eastman, 1911) and a half-mile service area for children (ALA, 1956), or optimal service areas for one or one and one-half miles in urban areas (ALA, 1943).

These parameters are based upon assumptions that not only do the majority of users or potential users live within these radii, but the radii indicate the maximum distance a user will travel to the facility. Also, when branches were placed closer together before the advent of the automobile, the one mile rule was established almost by default. Distance between library facilities and its effect on use, and subsequently upon market size, has been the subject of study (Grundt, 1968; Schlipf, 1973; Coughlin et al., 1972; Getz, 1978; Hayes & Palmer, 1983).

Size or average radius in miles of the market area for library facilities has also been the focus of study (Shaughnessy, 1970; Coughlin et al., 1972;

hlipf, 1973; Getz, 1980; Freestone & Beard, 1981; Koontz, 1990; Shoham al., 1990). A summary of studies of market area size nationwide indi- ted the average metropolitan library market has a radius of two miles Palmer, 1981).

All the quantitative standards were officially dropped in the 1960s Public Library Association, 1967) and the "outside-in" approach began. summary of currently used methods includes: justifying metropolitan ranch markets with a potential population of 30,000 served and the near- st branch is three to four miles away (Wheeler & Goldhor, 1962); assign- ng each library branch certain census tracts; using existing local govern- ent planning zones; or conducting a sample of registration or circula- on records, plotting the results on a large map, and drawing largest ercentages of populations proximate to each branch location (Van House t al., 1987). The latter sample survey method reinforces the estimate of ne market area thereby providing a more precise definition.

It is agreed that all approaches, at best, are rough estimates, and that ome communities' markets are easier to define than others. For ex- mple, a rural area with one library serving a small county would simply ave county boundary lines, while an urban area—e.g., the Los Angeles ounty Public Library with sixty or more branches—would be more com- lex, involving many more considerations such as distance to nearest fa- ility; transportation networks, topological boundaries (airports, parks, tc.), and the socioeconomics of the potential user market.

Across America there are an estimated 16,000 public library mar- ets. By and large, these are branch markets. Estimating and profiling ne geographic market area is the first step in analyzing the market of eople within the area to be served. This market profile of the commu- ity served is, of course, what all services and material offerings are sup- osed to be based upon (Public Library Association, 1979). Yet the li- rary manager, through lack of data and tools, is often forced to haphaz- dly estimate the market area. Accurate measurement and subsequent efinition of the market area then, must become a priority for library anagers and researchers alike to ensure that use of the library is opti- ized in communities throughout America.

EW TECHNOLOGIES FACILITATE LIBRARY ARKET ANALYSIS

A new technology can assist in the market analysis process. Geo- aphic information systems have burgeoned within the past ten years. A IS, as a computer-assisted system, is used for the capture, storage, re- ieval, analysis, and display of spatial data. Spatial data describe location

and geographic relationships among things and events. For the public library, this would describe the relationship between library use and the geographic market of users served.

Graphical maps are utilized in many GIS applications. It is estimated that over 80 percent of governmental decisions involve spatial data, making quick access to spatial data crucial to effective government operations. GIS technology is an attractive and efficient alternative to the manual processes of spatial analyses traditionally performed by public and private sector managers. The utility of GIS to estimate and define library market areas will be discussed and illustrated in this article.

PROBLEMS WITH, AND SOLUTIONS FOR, USING GIS

Problems

At present, there are some problems with GISs that should be noted before application is illustrated.

- *Data accuracy and error*–in a spatial setting, data error is especially hazardous. Setting map layers on top of each other, which are either gathered at different projections or collected at a rate of error from 5 to 100 feet, is serious business. Data can also be mislabeled. The amateur user of a GIS must be guided by any available expertise.
- *Data availability and procurement*–Desired data may not always be available. Fortunately, because of the growing availability of computers in libraries, data collection regarding library use can be automatic. The *Public Library Data Service Statistical Report* (PLA, 1988-1994) is a summary of important field data. The U.S. Census Bureau market data have been online since 1980. This type of summary data collected at higher levels and distributed widely saves tremendous cost to users. Data procurement is the most expensive aspect of GIS.
- *Very steep learning curve*–GIS is still difficult to use. Unfortunately, it is something you need to work with almost daily to be familiar with all aspects of the technique. But as counties and other government entities acquire GIS, the library manager may simply need to understand the analytical capabilities of GIS and know what questions to ask.
- *Expensive hardware and software*—until recently, GIS could not be purchased for under several thousand dollars. Now software packages are being produced that cost under $1,000.

Solutions

Problems associated with GISs are being solved, and access by library managers is more realistic as more users come to the GIS market thereby creating a need for more user-friendly GISs.

New Computerized Data Products. New computerized products from the U.S. Census Bureau that are utilized within a GIS framework are inexpensive and widely available. TIGER (Topologically Integrated Geographic Encoding and Referencing) line files are computerized computer-readable maps containing graphical linework images of nearly every street in the United States. TIGER files are inexpensive and ultimately usable by most GIS software. In addition, all the data gathered from the decennial census can be referenced to lineworks depicting geographic features, such as census tracts,[2] in the TIGER file. Thus, these socioeconomic data can be integrated into a GIS database using TIGER line files as a basis. A market profile that includes relevant census data elements such as age, race, sex, income, education levels, etc., for a given geographic area, can be produced from the GIS database. Library use data can be entered as another layer and viewed graphically within an analytic framework with other data (e.g., census, market boundaries, etc.).

While geographic information systems are traditionally used in areas of land management, natural resources, and highway planning because of the inherent spatial nature of these entities, private and public sector managers are beginning to see the utility of GIS for demographic market analysis. Many counties are now purchasing, or have purchased, GIS software for land management and planning. Agencies, such as libraries, desiring demographic analysis, can benefit from such local GIS purchases by developing their own applications for use with the local GIS software and hardware.

MARKET ANALYSIS

As discussed earlier, before any decision can be made regarding size and location of facility and materials and services that are offered, an estimate and profile of the library market area must be derived.

This first aspect of the market analysis consists of three questions:

1. How large is the current market (current geographic market and population size estimate)?
2. Who is the market (market definition and profile)?
3. What is the likely future size of the market (market forecasting)?

There are two remaining tasks within the market analysis that must occur after measurement and identification of the market area. The second is market segmentation, which is the process of determining the main groups to be served within the market area. The third is consumer analysis, determining the characteristics of users, specifically their needs, perceptions, preferences, and behavior (Kotler, 1982). The second and third steps are outside the scope of this discussion with the exception of identifying the demographic characteristics of users and the levels of library use. A GIS can greatly facilitate all tasks of the market analysis through the four powerful capabilities discussed later.

GIS ANALYTICAL CAPABILITIES FOR MARKET ANALYSIS

A useful classification of GIS analytical capabilities is provided by Thrall & Elshaw (1993). They categorize these capabilities into description, explanation, prediction, and judgment activities.

- *Description* documents and describes the spatial landscape (e.g., where are the census tracts with more than 35 percent of the population between the ages of 0 and 18, or which census tracts have a population with more than a 50 percent black population?).
- *Explanation* analyzes the phenomena that are found in the description phase (e.g., library usage is low for a particular branch because 20 percent of the population is on public assistance, 37 percent are 65 or older, and only 10 percent of the households are occupied by couples with children). Research indicates that all these characteristics are usually associated with low use markets (Koontz, 1990).
- *Prediction* uses modeling and statistical analysis to predict changes in a particular variable based on changes in other variables (e.g., systemwide library use will increase 20 percent when a new branch opens in a quadrant which is at present unserved).
- *Judgment* (or prescription) uses the findings of the first three types of analysis to prescribe an action (e.g., a long-range systemwide facility location and service plan).

For purposes of this presentation, the analytical capabilities of description and explanation will be used to estimate, measure, and define and profile library market areas.

GIS FOR MARKET ESTIMATION AND PROFILING

Representative uses of a GIS in a public library arena setting for market estimation and profiling by a library manager will now be presented. The public library setting that is used is the Evansville-Vanderburgh County, Indiana, public library system. The director provided the author with data from the county's library system.

A REVIEW OF THE EVANSVILLE-VANDERBURGH COUNTY PUBLIC LIBRARY SYSTEM

The Evansville-Vanderburgh County Public Library System has a central library, seven branches, young adult literacy outreach, homebound delivery, nursing home collections, and talking books services. An estimated population of 167,000 is served.

The East and West branches were the first libraries built in the newly formed Evansville Public Library in 1913. The Stringtown branch opened in 1939, following suburban growth outward from the downtown. Like many library systems across the country, the 1960s and 1970s were a time of expansion and construction due to the availability of funds provided by the Library Services Act in 1956 and the Library Services Construction Act in 1964. On the third level of growth outward from the inner city ring and beyond Stringtown, the McCollough Library (1965), the North Park Library (1968), and the Oaklyn Library (mid-1970s) were built in response to sprawling urban growth and the availability of funds.

The Red Bank Library was opened in 1991 in the University Shopping Center and draws users from farther distances due to traffic from diverse groups coming to university functions. A new branch for the northeast quadrant is also being considered and will be discussed in a later section on market definition.

MARKET ESTIMATE AND MEASUREMENT

As discussed earlier, geographic determination of market area is difficult. This is true not only for library managers but also for any manager of a store or service that is traveled to by its customers or users. Retailers have often used radii for store markets in order to generalize and identify key characteristics within the circles. Yet marketing consultants readily agree that polygons or specified market shapes are, and should be, unique to each location. These irregular service or market boundaries are more difficult to determine (Reid, 1995). A GIS facilitates a variety of ways that market boundaries can be defined, including irregular noncircular market areas. These methods, when employed by the library manager, basically reflect the more modern "outside-in" approach. Five graphical approaches to market measurement are discussed below. Market definition in conjunction with these measurements will be discussed and illustrated next. Definition describes who (socioeconomic census data) lives within the designated geographic areas.

Approaches to Market Measurement

There are five approaches to market measurement:

1. *Assigning each library branch a certain number of census tracts.* The Evansville-Vanderburgh Public Library assigns census tracts to each branch.
2. *Determining block groups[2] within the census tracts assigned to each branch market.* This provides further opportunity for analysis of smaller portions of the geographic library market area.
3. *Determining a branch market through overlay of zip code boundaries.* The value of zip code boundaries is important when a library records user zip codes, identifying where users reside.
4. *Determining branch markets by assigning equal portions of the population to the nearest existing facility.* This is a modeling[4] technique, location allocation which simply assigns each member of the population to the nearest facility, in this case a library branch.
5. *Determine a branch market by assigning a certain mile radii to be served.* This is a generalized approach, usually used by managers for a standardized point of comparison of key features. This is the average market radius of a metropolitan branch market (Palmer, 1981).

While these market measurement methods are not exhaustive, they show the dynamics and versatility of GIS in measuring and determining geographic library markets.

Market Definition and Profile

In order to answer who resides within these geographic areas, such as census tracts, block groups, zip codes, equal areas and circles, and ultimately, within the library market area, however defined, U.S. Census data must be attached and geo-coded to these areas. These data form another layer that can be displayed in the GIS environment.

There are literally hundreds of variables to select from in the census data. Each manager must know which variables are relevant to their user or customer. Research in the library field (Koontz, 1990) recognizes certain broad variable groups that are strongly associated with library use. These variables are also recorded by the U.S. Bureau of the Census. The nine broad variable categories include: (1) population (Palmer, 1981); (2) sex (Zweizig, 1973); (3) race (International Research Associates, 1968; Koontz, 1990); (4) age (Kronus, 1973; Hayes & Palmer, 1983); (5) family life cycle (represented by the census data categories of households with social security) (Hayes & Palmer, 1983), public assistance (Marketing Institute, 1988), or a female head of household[5]); (6) owner occupied housing (Zweizig, 1973); (7) income (Coughlin et al., 1972; Schlipf, 1973; Bennett & Smith, 1975; Getz, 1978; Van House, 1983); (8) education (Kronus, 1973; Zweizig, 1973; Hayes & Palmer, 1983); and (9) vehicles per housing unit (D'Elia, 1980; Gallup, 1976).

Thirty-three variables among the broad categories are initially measured and analyzed for each facility's market area (see Appendix A for a full listing of these variables).

The five types of geographic market areas, as measured by various boundaries, include census tract, block group, zip code, equal area and radius, and will define the market population of the Red Bank library branch market area with the use of GIS. Because census tracts and the block groups within represent the same geographic area in total, the numbers associated with each variable will add up equally. The benefit of block group information is to scrutinize and analyze a smaller geographic area.

Zip code information, in general, provides an "inside-out" look at who uses the library. For example, if user registration includes zip code information, a graphical display could be developed which would be useful in determining where the largest or smallest percentage of users live, how far most travel to the library, or perhaps why some travel to another library rather than the closest (e.g., special holdings, location, hours, etc.). Zip code data can also be used for direct mail purposes to publicize library services and programs to target populations—e.g., announcing an English literacy program to a heavily Hispanic neighborhood. This would be a benefit of using census block group, zip code, and library data in combination and graphically displayed in one environment.

Equal market area modeling (assigning population in equal amounts to nearest branch) offers an opportunity to see projected gaps or overlaps in service.

The radius, when applied at differing increments, can be used more successfully when it is known where percentages of users live. For example, do over 75 percent live within a mile or where does the fall-off occur? The circle also offers a standard point of comparison of key features within markets.

Each of the above methods is complementary in strength in providing a general description of the market area. These methods should be considered the "first cut" at market estimate and subsequent profile. For a more precise estimate and profile, a survey of user residences should be made. Each facility in the system has an impact on all others, and a review of all facility markets should be made. A review of gaps and overlaps in service is then possible.

Further Market Definition

The utility of GIS in market definition, and the enormous amount of information that can be provided for any geographic area, is illustrated in the discussion above. But more precise information can also be obtained. The following scenarios will illustrate what information library management may need to provide.

Scenario One. In preparation for planning the summer reading program, the library systems' children's librarian wants to identify the percentages of census tracts with over 35 percent of children 0-18 in age.

Scenario Two. A grant opportunity is available from a private foundation fund to provide literacy outreach services in majority black neighborhoods. The grant writer for the library would like to identify those census tracts within any library market that are over 50 percent black. The Eastside library appears to serve this group.

Scenario Three. It is time for the annual budget request to the county commission. The library director simply wants to know which library markets meet the higher quartile of annual per capita circulation as reported in the *Public Library Data Service Statistical Report* (Public Library Association, 1992). The higher quartile reported for systems serving 100,000 to 249,000 is 8.3 per capita. The Evansville-Vanderburgh County Public Library serves 167,000.

Scenario Four. The library system director is considering establishing a new branch in the northeast quadrant that is presently unserved. Industrial growth is presently taking place, and residential growth is predicted within the next five years. The director needs to know what is the current population, and what is predicted (this will be obtained from the local planning department), and also needs a review of the topography and major roads in order to review the proposed site at the junction of Interstate 64 and Morgan Avenue.

The library's criteria for new branches includes a population base of at least 25,000 to 30,000 within a two mile radius. Note that, at present, the population is only 4,900 within the two mile radius. The planning department projects approximately 10,000 more people by year's end. This is 10,000 short of the prescribed number recommended for a branch.

These four scenarios illustrate the dynamics and power of using a GIS for market definition and library market profiling. To have a myriad number of data sets collapsed into one environment for all types of analysis places powerful and much needed tools in the hands of the library manager.

SUMMARY

While stone walls do not a prison make nor iron bars a cage, yet neither do circles or preset lines necessarily make a library market area. A GIS provides the library manager with an opportunity to better measure market areas and subsequently define those markets in a complex dynamic online environment. The goal is one of offering the best possible

materials and services to potential and actual public library users who are guided by community standards and the policies and procedures of the library.

As the twenty-first century looms, the public library is once again being challenged by new media and information access technology. While digital online libraries-without-walls are continually discussed, the geographic place of the library-with-walls within the commmunity is simply heightened by these discussions. Access to burgeoning online data can only be possible if public libraries as unique public information agencies assure equitable access to the nontechnical elite and the information poor by being strategically placed geographically. A GIS will play a key role in helping public library managers meet this critical goal.

APPENDIX A

Census Market Variables

Persons - population
Families
Households
Females
Whites

Blacks
Indians
Asians
Hispanics

Age 3 to 4
Age 7 to 9
Age 10 to 17
Age 0 to 18
Age 18 to 19
Age 20 to 29

Age 30 to 44
Age 45 to 59
Age 60 to 64
Age 65 to 74
Age 75 and over

Education up to grade 9
Education grade 9 through 12th
Education - High School Graduate

Education some college
Education AA degree
Education Bachelor's degree

Households with earnings
Households with social security income
Household with public assistance
Number of houses
Number of owned houses

Number of owner occupied hou
Households with one vehicle
P = Percentage of the above grou
Temp1 field is library use per cap

NOTES

1 A market area is the geographic area from which a library draws most of its users (Ghosh & McLafferty, 1987, pp. 12-13).

2 A census tract is a large neighborhood generally with a population between 1,500 and 6,000 (Myers, 1992, p. 16).

3 A block group is a smaller subdivision within a census tract (Myers, 1992, p. 18) providing further geographic definition of a market area.

4 A model is a representation of relevant properties of reality, and models are usually mathematical. Variables are identified, defined, and measured. Models can trace various alternatives in the decision-making process. The relationships within models can describe and explain the past, provide control for the present, and enable prediction. The more relevant details there are in a model, the more opportunity there is for a true representation of reality (*Library Planning and Decision Making Systems*, 1974, pp. 76-85).

5 These variable categories are used to assess the importance of these lifestyle situations. Each may also serve as a measure of low income.

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The Effect of Distance on Public Library Use: A Literature Survey*

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CONTENTS

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I. INTRODUCTION

The relationship between man and his spatial environment is an intricate one. An individual is likely to use facilities located within his/her normal range of travel. However, efforts to provide services within the range of all possible users may result in inadequate provision of resources at each dispersed location.

Library administrators have long recognized this need for a balance between convenience to the user and provision of adequate service. Over the years, surveys of library users have indicated the limits of local constituencies. Parallel observations have been made in a host of other fields, from the definition of residential choice in relation to the journey to work, to shopping pattern observations, and choice of leisure activities (Haggett et al., 1977). Some of the models derived from these fields of study have been applied to the library situation (Buckland, 1978; Elton and Vickery, 1973; Hamburg et al., 1974; Kantor, 1979). However, the wealth of resources available in the public facility planning literature remains largely untapped. A consolidation of the literature representing the librarian's practical experience and the planners' theoretical expertise would facilitate understanding of the complex role distance plays in library use.

II. HISTORICAL PERSPECTIVE

The physical structures which house our libraries present both a challenge and a constraint. Their present sites and condition affect future development, while their form of construction and pattern of distribution are rooted in concepts of the past. A brief examination of trends in library location theory provides a basis for understanding the present situation.

In the 1870s, an analysis of applications for registration convinced the Board of Trustees of the Boston Public Library that "inconvenience of access to the Central Library deprived the people of East Boston of their natural use of that great collection" (Greenenough, 1871). As a result, the East Boston branch became America's first formal branch library (Carroll, 1966). By the turn of the century, the American Library Association's *Manual of Library Economy* had this recommendation: "...the city which provides branch libraries not more than a mile apart is not in danger of overdoing its library facilities; while in densely populated parts of large cities two or three times as many branches may be needed" (Eastman, 1911).

The 1912 Annual Report to the Board of Trustees of the Chicago Public Library offered this comment concerning their recent branch acquisitions:

> It is to be regretted that the extension could not be carried out pursuant to a carefully mapped plan based on population, well-defined districts, and other factors which should control. Instead, perforce, the branches have been located as offered...(Chicago. Public Library, 1916, p. 5).

Four years later, the city approved a bond issued later considered "a landmark in library history" (Joeckel and Carnovsky, 1940, p. 41). Its goal was to supply "library service within walking distance of home for every person in the City of Chicago who can read or wants to use books" (Chicago Public Library, 1916, p. 3).

By 1927, an ALA survey numbered among Class A library systems (100,000 volumes or more): 7 systems with branches less than 1/2 mile apart on an average, 11 systems within the 1/2-1 mile range, and 6 additional systems with branches under 1 1/2-miles apart (American Library Association, 1927). Florence Goodenough (1926) evaluated the impact of these building efforts in her statistical analysis of library services among major U.S. libraries. She found that accessibility was second only to funding as a key factor effecting library circulation. For example, Columbus, Ohio's single library served a population of 268,000 and averaged 1.11 volumes per capita circulation. In contrast, Cleveland, Ohio had multiple branches, each serving an average of 16,000 people with an average circulation of 6.54 volumes per capita.

On a local level, examination of registration and circulation records was evolving as an evaluative tool. Pilcher (1923), Jones (1926), and Horowitz (1933) presented landmark surveys of system-wide use, while Potvliet (1928) and Wert (1937) focused on individual branches. Douglas Waples (1932), in an investigation designed to determine the reading interests most closely associated with library usage, discovered that proximity to a branch had a greater influence on patronage levels than any specific subject interest. Laurel Krieg (1939) corroborated this, noting that 55 percent of the patrons surveyed lived within 10 blocks of the library. A user study by Gray and Monroe (1929) noted that accessibility was a definite factor in book use. The authors pointed to the success of the County Library Service in California as support for the theory that accessibility increases consumption. Evans (1976) details a number of surveys in his history of community analysis.

One mile, a distance suggested by Eastman in 1911, was accepted as an early service radius (McDiarmid, 1940). The American Library Association, *Post-War Standards for Public Libraries* (1943) set 1-mile limits for optimal service in urban library systems. In Britain, this became "pram-pushing distance" in Library Association literature (Library Association, 1952). Grundt (1968) noted that the distribution of libraries in Boston is such that a library branch is less than 1/2 mile from most homes.

These close-spacing policies gradually encountered resistance. The report of the Los Angeles Bureau of Budget and Efficiency (1949) clearly represents this counter-trend. Their survey indicated that a majority of patrons drove to the library, some travelling as much as 10 miles for service. With such obvious mobility, they concluded, it would be more economical if a district consolidated its facilities. Considerable economy of scale would result, and the resulting larger collections would offer more variety to patrons.

This argument was strengthened considerably with the publication of the massive Public Library Inquiry (Berelson, 1949; Leigh, 1950). Their recommendation for consolidation was echoed by the library location prophet of the 1950s and 1960s, Joseph Wheeler. The Wheeler doctrine stressed the importance of attractive buildings, business and shopping center locations, and extensive consolidation of services (Wheeler, 1958, 1967). His empirical approach, with emphasis on learning from the mistakes of the past, fostered a burgeoning of evaluative location literature (Bertram, 1963; Freestone, 1976; Freestone, 1978; Vance, 1960).

At a recently held symposium (Galvin, 1976) many of the topics discussed related to the public's perceived awareness of the library and the convenience of the journey there. Awareness was characterized by the relative "visibility" of the library in the community, by its association with other commercial and service institutions and by the image evoked by the surrounding neighborhood. Perceptions of convenience were influenced by the terrain, both natural and man-made barriers, presence or absence of long stairways, availability of parking space, harzardous traffic conditions, etc.

Observations of this type, while significant, tend to focus on the site itself rather than on the public served. Dunstan (1977) notes that many library location studies start with the assumption that the library must be placed on available public land. This disregards the location's effect on use. Potential user access should be considered as the governing factor, location as the variable.

III. CURRENT TRENDS

Concern for the immobile patron has become an increasingly significant topic in the last decade. Martin (1969), Arthur D. Little and John S. Bolles (1970), and Healy et al. (1980) recognize the need to maintain services at seemingly inefficient branches which serve mainly the young, the poor or the elderly. Keith Doms (1967, pp. 931–932) noted that

> ...for far too many years, public library planning and development has been derived from a mysterious essence seemingly comprised of one part intuition, one part information, and one part assumption. Admittedly, how many would have been better if one had possessed a fuller knowledge of the user and the nonuser.... What kinds of patrons need what kinds of materials? What are different use patterns in different clientele areas? While there have been useful studies...in (the library's) relationship to the needs of large groups of disadvantaged persons, we are still confronted with major premises such as the well-established and pervasive point of view that quality of service is improved primarily through provision of fewer but larger units. ...Only recently several colleagues have suggested that perhaps we should resort to older patterns of service that have worked and that we ought to plan programs appropriate to the needs of the immobile as well as for those who are highly mobile.

Recent periods of fiscal austerity have led library administrators t consider consolidation of services (Getz, 1980). While consolidation may b economically advantageous, care should be exercised to consider the impa of closures on the particular patron groups involved. The library's publ should be considered in terms of differing levels of motivation towar library use (Consad Research, 1968).

The following section will consider the relationship between the di tance separating an individual from a library and the use that individua makes of the library. After the library user has been characterized, a publi facility modelling theory will be discussed briefly in relationship to librar location. Equity, "fairness, impartiality or equality of service" (Savas 1978, p. 802) will be discussed in conjunction with decisions involving th opening of new branches and the closing of existing facilities.

IV. DISTANCE AND THE LIBRARY USER

One means of examining the effect of distance as a deterrent to library use is to analyze the use of libraries in rural or poorly served areas. Hodgso (1946) concludes that library use in non-served areas of rural Indiana is limited to a core population (under 5% of all residents) that has sufficien interest in libraries to visit them during their trips to town. Schuler an Turbeville (1948) observe that less than 10 percent of Michigan farmers livin over 5 miles from a site take advantage of library services. Chandler an Croteau (1940) indicate that a heavy concentration of users on Prince Ed ward Island live within a mile of a library. Luckham (1973) observes similar concentration of users within a 1-mile radius in several Englis towns. Studies of extended library systems (Colorado Market Research 1974; Elrick and Lavidge, 1977; National Educational Resources Institute 1972) show somewhat lower percentages of patrons within the first mile However, the majority of users reside within a five-mile radius.

Linear distance from a geographic location may not give an accurate representation of the relative land areas involved in a survey (Bennett and Smith, 1975). A system of normalization, whereby user attendance may be

weighted by the area served at a given distance, is utilized in this paper to emphasize the difference between distance and area. Figure 1 indicates the normalization technique used.

Tables I to IV present a comparison of a number of library user surveys. Results are given in terms of the percentage of patrons residing within a given band from the library and in relative percentages after normalization. Percentages may not total 100 percent since some patrons may live beyond the region included in the normalized analysis.

Some of the variation observed between the studies cited in these tables may be due to differences in survey technique. For example, the source of information may affect the accuracy of the distance measurement. Studies which rely on the respondent's perceptions of distance and time may be less reliable than those which use street addresses.

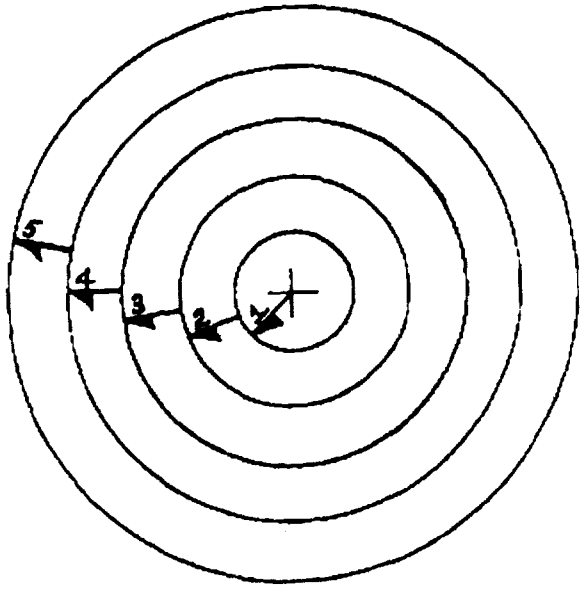


Figure 1. Normalization Procedure

A library's service area is assumed to approximate a circle with area $A = \pi r^2$. The unit r represents a standard increment from the library site. The area of a ring of width r is equal to the area of a circle πr^2 minus the area of the preceeding circle, $\pi(r-1)^2$. Succeeding zones are related as follows:

Intervals	Determination of Normalization Constant					
	r unit	πr^2	$-\pi(r-1)^2$		Area	Ratio
1/4 miles, 1/2 mile, 1 mile	1	$\pi 1$	− 0	=	$\pi 1$	1
0–1/4 mile, 0–1/2 mile, 0–1 mile	2	$\pi 4$	− 1	=	$\pi 3$	3
1/4–1/2 mile, 1/2–1 mile, 1–2 miles	3	$\pi 9$	− 4	=	$\pi 5$	5
1/2–3/4 mile, 1–1–1/2 miles, 2–3 miles	4	$\pi 16$	− 9	=	$\pi 7$	7
3/4–1 mile, 1–1/2–2 miles, 3–4 miles	5	$\pi 25$	− 16	=	$\pi 9$	9
1–1–1/4 miles, 2–2–1/2 miles, 4–5 miles						

TABLE I

Distance of Users from Libraries in 1-Mile Intervals[a]

Locality (Source)	# Patrons	0–1 Mile		1–2 Miles		2–3 Miles		3–4 Miles		4–5 Miles	
		%	Norm.	%	Norm.	%	Norm.	%	Norm.	%	Norm.
Prince Edward Island (Chandler and Croteau, 1940)	24,498	56.7	56.7	6.3	2.1	7.7	1.5	7.6	1.1	6.3	0.7
Spanish Speaking Southwest, U.S. (National Educational Resources Institute, 1972)		35	35	30	10	15	3	5	0.7	2	0.2
Colorado Statewide (Colorado Market Research, 1974)		37	37	23	7.7	17	3.4	6	1.0	8	0.9
Illinois, Statewide (Elrick and Lavidge, 1977)	152	48	48	23	7.7	7	1.4	5	0.7		
Melbourne, Australia (Handfield and Hamilton-Smith, 1975)		25	25	23	7.7	28	5.6	14	2.0	7	0.8
United States Nationwide (Gallup, 1976)	1,200	21.3	21.3	21.7	7.2	17.7	5.5	11.1	1.6	3.4	0.5
Average[b]		33.2	33.2	24.2	8.1	19.0	3.8	8.2	1.2	5.1	0.6

% signifies percentage of users living within the stated interval.

Norm. indicates normalization; a process which compensates for differences in area between the center of a circular service zone and successive rings of equal width. Figure 1 defines the normalization process further.

[b]Data from the Prince Edward Island Survey was not included in the average since transportation available to users at that time period may differ substantially from the more recent studies.

[a]Percentages of patrons may not total 100 percent. Residents beyond the chosen intervals were not included due to difficulties in normaliza

TABLE II [a]

Distance of Respondents from Nationwide Libraries (Gallup, 1976)

Characteristics		#	0–1 Mile		1–2 Miles		2–3 Miles		3–4 Miles		4–5 Miles		χ^2
			%	Norm.	%	Norm.	%	Norm.	%	Norm.	%	Norm.	
Age	18–34	561	21.2	21.2	23.9	8.0	17.3	3.5	9.4	1.3	1.8	0.2	
	34–49	330	18.8	18.8	17.0	6.7	19.1	4.8	13.0	1.9	5.5	0.6	
	50+	300	24.0	24.0	22.4	7.5	17.0	3.4	12.3	1.8	4.3	0.5	
Sex	Male	554	22.7	22.7	21.0	7.0	17.3	3.5	11.2	1.6	4.7	0.5	
	Female	646	20.0	20.0	22.5	7.5	17.8	3.6	11.0	1.6	2.3	0.3	
Education	Current student	142	27.5	27.5	21.8	7.1	17.6	3.5	3.5	0.5	7.7	0.9	**
	Completed college	371	19.1	19.1	21.0	7.0	20.0	4.0	9.7	1.4	3.2	0.4	
	Completed high school	441	16.0	16.0	24.1	8.0	19.5	3.9	13.4	1.9	3.2	0.4	
	Completed grade school	244	29.9	29.9	19.3	6.4	10.7	2.1	13.5	1.9	1.6	0.2	**
Occupation	Professional & Business	228	17.6	17.6	24.1	8.0	18.0	3.6	9.2	1.3	4.4	0.5	
	Clerical & Sales	170	22.9	22.9	20.6	6.9	22.3	4.5	8.2	1.2	0.6	0.1	
	Manual & Farmer	294	21.7	21.7	21.5	7.2	16.3	3.3	10.5	1.5	3.4	0.4	
	Non-labor force	357	20.7	20.7	22.2	7.4	14.3	2.9	12.3	1.8	2.5	0.3	
Readership Scale	Heavy	300	20.8	20.8	22.2	7.4	18.7	3.7	11.2	1.6	3.3	0.4	
	Medium	389	22.6	22.6	23.7	7.9	16.7	3.3	13.1	1.9	3.9	0.4	
	Light	611	25.8	25.8	18.1	6.0	12.3	2.5	9.0	1.3	2.6	0.3	***
	Non-users	1,520	16.2	16.2	16.4	5.5	11.0	2.2	9.0	1.3	3.8	0.4	

[a] χ^2 tests were conducted by the author to compare individual user groups (eg. current students) with the nationwide average (Table I-bottom line). Levels of significance are indicated as follows:

**Significant at the .01 level

***Significant at the .001 level

? 19.6% of non-users did not know the location of a library.

Continuation of TABLE II

Distance of Respondents from Nationwide Libraries (Gallup, 1976)

Characteristics	#	0–1 Mile		1–2 Miles		2–3 Miles		3–4 Miles		4–5 Miles		χ^2
		%	Norm.	%	Norm.	%	Norm.	%	Norm.	%	Norm.	
Stage in Life Cycle												
Married with children												
Under 35	225	19.6	19.6	24.0	8.0	16.0	3.2	12.9	1.8	0.4	0.0	
35 & Older	295	21.1	21.1	20.7	6.9	13.9	2.8	15.3	2.2	3.7	0.4	
Married												
Under 35	88	21.6	21.6	14.7	4.9	18.1	3.6	5.7	0.8	1.1	0.1	*
35 & Older	189	23.8	23.8	16.9	5.6	21.1	4.2	11.1	1.6	3.7	0.4	
Single												
Under 35	241	23.2	23.2	27.3	9.1	17.4	3.5	7.5	1.1	3.3	0.4	
35 & Older	132	19.7	19.7	19.0	6.3	21.9	4.4	10.6	1.5	6.8	1.0	
Region of the United States												
New England	78	14.1	14.1	28.2	9.4	17.9	3.5	15.4	2.2	1.3	0.2	
Mid-Atlantic	223	33.1	33.1	16.1	5.4	17.9	3.5	7.2	1.1	2.2	0.2	***
East Central	216	23.6	23.6	13.4	4.5	14.8	3.0	19.9	2.8	6.0	0.6	***
West Central	115	8.7	8.7	33.0	11.0	25.2	5.0	12.2	1.7	7.0	0.8	***
Southeast	217	18.9	18.9	23.9	8.0	12.5	2.5	10.1	1.4	2.3	0.3	***
Southwest	77	6.5	6.5	10.4	3.5	23.4	4.7	14.3	2.0	2.6	0.3	***
Rocky Mountain	53	18.9	18.9	9.4	3.1	33.9	6.8	13.2	1.9	3.8	0.4	*
Pacific	221	13.6	13.6	32.1	10.7	15.0	5.0	3.6	0.5	2.3	0.2	***

*Significant at the .05 level

**Significant at the .01 level

***Significant at the .001 level

TABLE III
Distance of Registrants from Libraries in ½-Mile Intervals

Locality	(Source)	# Patrons	0–½ Miles %	0–½ Miles Norm.	½–1 Miles %	½–1 Miles Norm.	1–1½ Miles %	1–1½ Miles Norm	1½–2 Miles %	1½–2 Miles Norm.
Urban Systems										
Detroit, Michigan	(Ulveling, 1939)	1,360	42.0	42.0	37.0	12.3	13.0	2.6	3.0	0.4
Southhampton, England	(Luckham, 1969)	46,212	41.0	41.0	42.0	14.0	11.0	2.2	6.0	0.9
Melbourne, Australia*	(Healy et al., (1980)	1,732	36.9	36.9	33.4	11.1	17.0	3.8	5.1	0.7
Average			40.0	40.0	37.5	12.5	13.7	2.9	4.7	0.7
Dispersed Systems										
Alliance, Ohio	(Krieg, 1939) Men		20.1	20.1	35.4	11.8	14.4	2.9	12.3	1.8
	Women		25.4	25.4	30.6	10.2	111.4	2.3	15.6	2.2
	Total		23.0	23.0	32.8	10.9	12.8	2.6	14.0	2.0
Kansas City, Kansas	(Quinly, 1948)	711	14.0	14.0	17.0	5.7	26.0	5.2	16.0	2.3
San Bernardino, California	(Hart and Palmer, 1966)		12.0	12.0	17.0	5.7	19.0	2.8	14.0	2.0
Findlay, Ohio	(Bennett and Smith, 1975)	244	12.0	12.0	18.0	6.0	25.0	5.0	27.0	3.9
Syracuse, New York	(Zweizig, 1973)	1,042	34.0	34.0	20.0	6.7	16.0	3.2	18.0	2.6
Average			19.0	19.0	20.1	7.0	19.8	3.8	17.8	2.3

*Distance in 1-kilometer intervals (approximately 0.6 miles)

TABLE IV
Distance of Users from Libraries in ¼-Mile Intervals

Locality (Source)	# Patrons	0–¼ Mile %	0–¼ Mile Norm.	¼–½ Mile %	¼–½ Mile Norm.	½–¾ Mile %	½–¾ Mile Norm.	¾–1 Mile %	¾–1 Mile Norm	1–¼ Mile %	1–¼ Mile Norm.	1¼–1½ Miles %	1¼–1½ Miles Norm.
Kansas City, Missouri (Community Studies, 1952)	37,221	11	11	36	12	20	4	20	2.9	6	0.7	4	0.4
Southampton, Eng. (Luckham, 1969)		17.8	17.8	23.9	8.0	17.2	3.4	10.1	1.4				
Cheshire, Staffordshire and Lincoln, Eng. (Taylor and Johnson, 1973)													
Branches	31,882	20.0	20.0	25.6	8.5	17.1	3.4	10.9	0.6				
Central	16,607	8.3	8.3	11.2	3.7	13.4	2.7	13.9	2.0				
Greenwich, Eng. (London Borough of Greenwich, 1974)	2,000	23.0	23.0	35	11.7	16	3.2	9	1.4	5	0.7	3	0.3
Philadelphia, Pennsylvania (Coughlin et al., 1972)		21.5	21.5	29.8	9.9	22.0	4.4	12.8	1.8	8.0	0.9	5.9	0.5
Age Groups: Under 9		28.6	28.6	39.0	13.0	15.7	3.1	8.5	1.2	5.8	0.6	2.4	0.2
10–13		25.7	25.7	33.2	11.1	22.7	4.5	9.3	1.3	6.0	0.6	4.1	0.4
Over 14/in high school		19.3	19.3	26.1	8.7	23.9	4.8	14.1	2.0	9.3	1.1	7.2	0.7
Adult		16.5	16.5	26.0	8.7	21.9	4.4	16.8	2.4	10.8	1.2	8.1	0.7
Average*		18.7	18.7	30.1	10.0	18.5	3.7	12.5	1.8	6.3	0.7	4.3	0.4

*Average for branches excludes Central library at Cheshire, Staffordshire and Lincoln, England.

Sampling techniques may also affect the results. A random sample of a community may be unbiased with respect to distance from the library, while an in-house survey may tend to favor the frequent user. Elrick and Lavidge (1977) note this in their examination of Illinois residents. On site interviews indicated that 35 percent of those interviewed came from within 7 blocks of the library; 48 percent from within 1 mile. A concomitant telephone survey listed 27 percent of the respondents living within 7 blocks, while 50 percent lived within a mile.

A variable which remains unstated in most library surveys is the physical distance between library branches. Getz (1980) analyzes 31 library systems in the United States. On the basis of locations per hundred square miles, he notes that strictly urban systems average 32.11 sites (1-mile service radius); metropolitan systems average 4.00 locations (2.8-mile radius); and suburban systems average 3.05 branches (3.2-mile radius) per 100 square miles.

Distribution of the population served represents another variable. If 2 miles is selected as a basis of comparison, patronage may be seen to increase as respectively denser areas of population are examined. Thus, the generalized surveys listed in Tables I and II have an average of 57.4 percent of all users living within 2 miles. For the dispersed systems listed in Table III, 76.7 percent of all patrons live within 2 miles, while the urban systems cited in Tables III and IV have over 90 percent of all users coming from within the 2-mile zone.

At first glance, the heavy concentration of urban branch library users within a 1/2 mile of the library may seem exceptional. Part of this effect is tautological. If facilities are located at frequent intervals, then the user is more likely to choose a branch within his/her zone of greatest familiarity. Thus, if all other factors remain equal, branches spaced 1 mile apart should draw their greatest patronage from within 1/2 mile of the site (Hodgart, 1978).

Mode of Travel

The distance a patron is willing to travel is affected by the available means of transport. Surveys of non-users frequently indicate lack of transportation as an important factor in non-use (D'Elia, 1980; Gallup, 1976). Transportation can be a particularly important problem to the elderly (Smith, 1977). The nationwide Gallup survey (1976) cites transportation-related problems as the cause of 15 percent of the total reasons for non-use.

The type of transportation available may affect the perceived cost of the trip to a user. Citizens using public transportation may readily place both time and monetary values on library visits. Walkers may perceive the trip in terms of time and physical effort expended, while auto drivers may place relatively less emphasis on the cost of the trip itself, within certain

limits. In addition, walkers are more apt to view a library visit as a single-purpose trip, while automobile drivers are more apt to include a library visit with other stops in a multi-purpose trip (Mortimore et al., 1967).

Hodgart (1978) suggests that public facility planners should concentrate their attention on the problem of serving the least mobile group, the walkers. Since auto drivers have more inelastic transportation requirements, they may be able to adjust accordingly.

Hayes (1980) examines the relative response to distance for walkers and drivers in the Los Angeles Public Library System. Figure 2 indicates that use falls off sharply for both classes of patrons. However, the slope of the walker's curve indicates a greater sensitivity to distance for patrons arriving on foot than for those driving.

Wilson (1970) suggests that the mathematical expression of distance be varied to indicate the differing responses of individuals to walking and driving situations. Haynes (1974) summarizes a number of animal and human behavior studies which indicate the usefulness of alternative distance functions. Cliff and Ord (1975) indicate the significance of differing expressions for distance in relationship to geographic modelling.

Relative use of various modes of transport is listed in Table V. Some travel patterns may be quite localized. Access to central San Francisco via BART (Bay Area Rapid Transit) leads to an unusually high use of reference libraries by patrons from outlying areas. Public transport becomes an important factor in this instance.

A factor which is rarely considered in library surveys is the distinction between users who arrive via a given mode of transport out of necessity, and those who chose a method on the basis of convenience or preference. This distinction is particularly important in terms of the walker living within a convenient distance of the library. A car may be viewed as an impediment to such a patron, since parking the car may entail more effort than walking to the site. This question is particularly important in urban systems with closely spaced branches, since the number of patrons who could adapt to more dispersed facilities may be difficult to determine.

Bonser and Wentworth (1970) offer some insight into the relative attractiveness of walking versus driving. Respondents to their survey were requested to define the distance of their library trip as "within walking distance" versus various driving time. A greater proportion of library users perceived the library as being within walking distance than did their counterparts from the general public. This effect is particularly apparent among retired persons. (Table VI).

Elasticity of Demand

Motivation to attend a library has a profound effect upon use patterns with relationship to the distance of residents to public library branches. In the

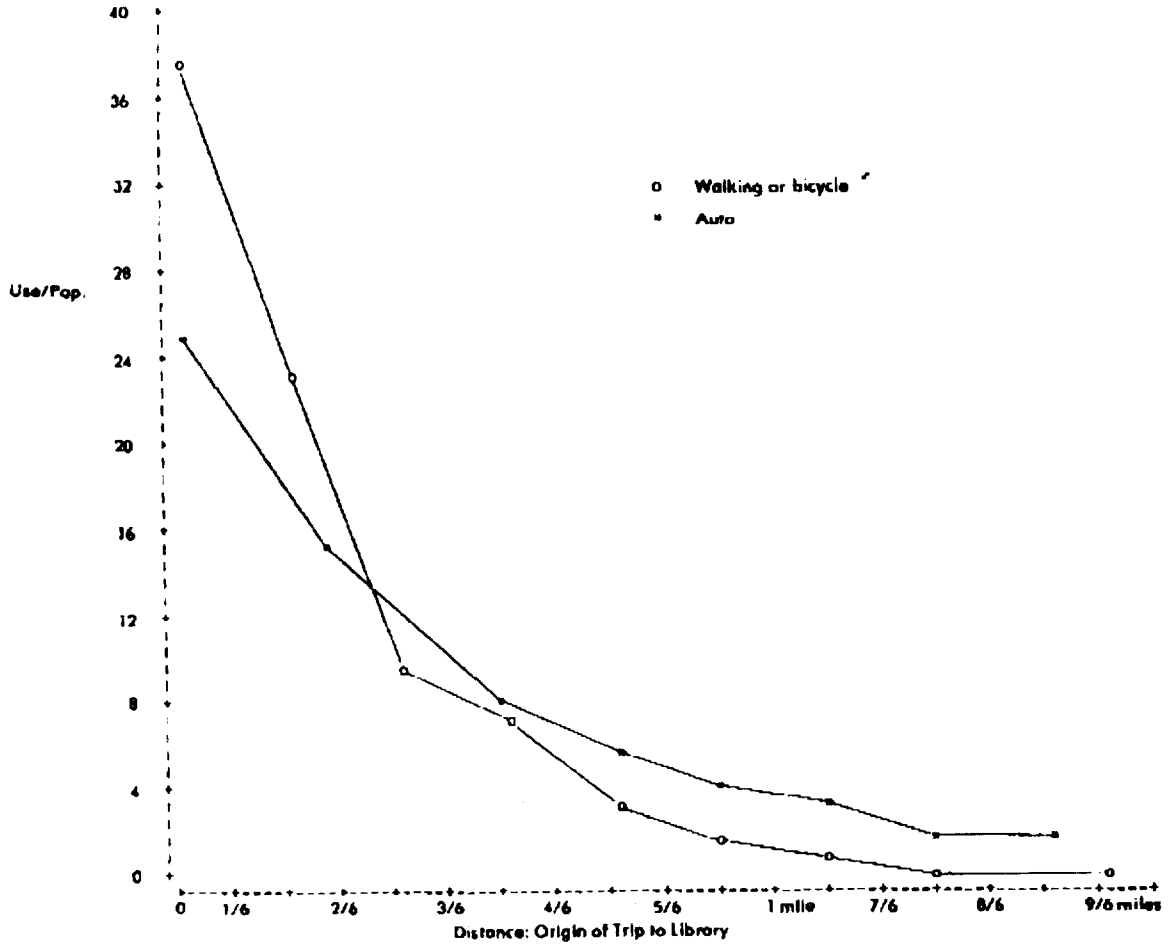


Figure 2. User Response to Distance—Walking Versus Driving (Hayes, 1980)

TABLE V
Modes of Transport

Locality (Source)	# Patrons	Automobile	Walk	Motorcycle/ Bicycle	Public Transport	Other
Extended Systems						
Nationwide (Gallup, 1976)	1,561	8.14	13.4	0.9	2.4	1.5
Illinois Statewide (Elrick and Lavidge, 1977)	152	75	21	3	1	
Idaho Falls, Idaho (Ahlstrom, 1968)	1,186	78.5	16.9	4.6		
Urban Branches						
Toledo, Ohio (Nelson Associates, 1968)	2,902	71.8	21.2		0.7	6.2
Sylvania County, Ohio (Nelson Associates, 1968)	572	77.4	18.4		0.5	3.8
Akron, Ohio (Tri-County Regional Planning and Blasingame, 1972)		78	19		2	1
Cheshire, Staffordshire and Lincoln, Eng. (Taylor and Johnson, 1973)	31,882	38.5	50.1	3.5	6.9	1.1
Wilmington, Delaware (Wilson and Figura, 1974)	4,241	81.4	13.4	0.9	2.4	1.9
San Francisco, California (Arthur D. Little and John S. Bolles, 1970)	5,800	31.4	56.5	1.6	6.6	3.9
Toronto, Ontario (Woodsworth et al., 1975)	2,191	24.0	63.0		22.6	0.7
Urban Reference Libraries						
Toledo, Ohio (Nelson Associates, 1968)	8,028	66.1	26.5		4.2	3.2
Cheshire, Staffordshire and Lincoln, England (Taylor and Johnson, 1973)	16,607	37.5	35.8	2.6	22.4	1.6
Baltimore, Maryland (South, 1975)	1,088	32.4	33.0		24.3	10.3
San Francisco, California (Arthur D. Little and John S. Bolles, 1970)	400	28.6	31.3	1.5	33.3	5.3

TABLE VI
Distance from Libraries as a Function of Occupation and Education
(Bosner and Wentworth, 1970)

Characteristics	Within Walking Distance		Drive 0–15 Min.		Drive 15–30 Min.		Drive Over 30 Min.		Don't Know	
	Users	G.P.	Users	G.P.	Users	G.P.	Users	G.P.	Users	G.P.
Occupation										
Farming		1		47		38		3		1
Unskilled	24.6	23.5	42.1	53.5	31.6	19.1	1.8	2.6	0	1.3
Skilled & Clerical	25.0	20.8	58.3	57.5	13.9	18.3	2.8	1.7	0	1.7
Management & Self-Employed	15.5	14.7	67.2	60.0	15.5	23.3	0	0.7	1.7	1.3
Professional	33.9	18.4	50.8	67.1	15.3	13.2	0	0	0	1.3
Retired	50.0	35.7	34.6	36.6	13.5	17.9	0	3.6	1.9	1.3
Education										
1–6 Years		26.7		53.3		20.0		0		0
7–12 Years	30.0	23.6	47.8	52.7	21.1	20.0	1.1	0	0	0
13–16 Years	26.9	16.0	53.8	60.6	17.3	19.5	1.0	1.7	1.0	2.2
17 + Years	25.4	18.8	57.6	66.7	15.3	14.5	0	0	1.7	0
Total	37	25	47	52	14	17	0	2	0	0

Users = 290 General Public = 906

language of the economist, the patron who will use a facility only if nearby exhibits elasticity of demand, while the patron who will travel g distances is highly inelastic in his/her demand for library services (Hodg 1978).

Bundy (1967) indicates that among patrons whose needs have not b met in a particular library, over half would travel to another library to tain the desired material. Gallup and New Jersey State Library (1976), plore the question of user elasticity by another means. Residents are as for their preferences between small libraries with limited resources wit walking distance of their homes, and larger libraries with greater select but located at driving distance from their residence. The smaller libra were preferred by a majority of those queried in these categories: u residents, persons with a high school education or less, those earning un $10,000, persons over 50 years of age, parents, and those not in the la force. Preference for larger libraries was most pronounced among resp dents in the 18 to 34 age bracket, businessmen, college graduates, and sin persons. Zweizig (1973) notes that the distance to the library may be m critical to the moderate user than either the frequent or occasional user

Sheppard (1979) calls attention to the "hidden-demand" problem public facilities. Once a service is initiated, its presence creates a demand the immediate vicinity. If a building has been constructed on a scale co mensurate with previously perceived demand, the unexpected presence new local patrons may cause overcrowding. This in turn may result i poor public image which may reduce ultimate use of the service. Shepp suggests inclusion of an accessibility factor within a planning scheme allow for this anticipated increment.

Elasticity of demand is related to a number of factors. Means of tra portation available to the patron is one. Another factor is the motivat the consumer feels toward obtaining the service. A difference in leve motivation may be observed in the time spent in travel to obtain servi Table VII indicates the difference in average trip time invested in a visit central library with respect to a branch. The relatively high proportion is another example of inelastic demand.

A Delaware library survey (Wilson and Figura, 1974) analyzes the of the public library for specific activities with relation to travel time (Ta VIII). Their statistics indicate that those with school-related studies more apt to travel less than 10 minutes to use a library, while those w work-related use will travel over 15 minutes to a library at a higher quency than the average respondent.

Shopping Patterns

Inclusion of a library visit in conjunction with other activities is a relati

TABLE VII
Distance of Users from Libraries in Travel Time*

Locality (Source)	# Patrons	Travel in Minutes:	Percent Patrons Responding					
		No. Ans.	0–5	6–10	11–15	16–20	20–30	Over 30
Central Libraries								
San Francisco, California (Arthur D. Little and John S. Bolles, 1970)	400	3.4	12.1	18.6	24.9	/-----30.3-----/		10.7
Toledo, Ohio (Nelson Associates, 1968)	2,346		/---23.8---/		/----36.9----/		/-----39.3-----/	
Lucas County, Ohio (Nelson Associates, 1968)	748		/---49.5---/		/----34.2----/		/-----16.1-----/	
Baltimore, Maryland (South, 1975)	812	25	13		/---21.6---/		/---------40.2---------/	
Pennsylvania "District Center" Libraries (Shoughnessy, 1967)	5,727		/---37.8---/		/----43.2----/		14.8	4.2
Branch Libraries								
San Francisco, California (Arthur D. Little and John S. Bolles, 1970)	5,800	2.5	37.9	30.0	16.9	/-----9.5-----/		3.2
Toledo, Ohio (Nelson Associates, 1968)	5,622		/---67.9---/		/----27.5----/		/-----9.6-----/	
Sylvania County, Ohio (Nelson Associates, 1968)	966		/---67.7---/		/----27.6----/		/-----4.7-----/	
Lucas County, Ohio (Nelson Associates, 1968)	2,110		/---78.3---/		/----14.4----/		/-----7.3-----/	
Akron, Ohio (Tri-County Regional Planning and Blosingame, 1972)			/---------68---------/			/-----24-----/		9.0
Baltimore, Maryland (Bundy, 1968)		6.8	34.2	28.4	14.6	7.2	5.4	3.4

*Mileage in terms of travel time varies with mode of transport. Variations in measurement periods preclude averaging.

TABLE VIII
Distance from Libraries as a Function of Activity
(Wilson and Figura, 1974)

Activity	# Patrons		0–5 Min.		6–10 Min.		11–15 Min.		16–20 Min.		21–30 Min.		31–45 Min.		45–60 Min.		Over Hour	
	Wil.	State	Wil.	State	Wil.	State	Wil.	State	Wil.	State	Wil.	State	Wil.	State	Wil.	State	Wil.	State
Use within past year	77	1,406	22.1	37.2	32.5	32.1	33.8	18.8	10.4	8.0	1.3	2.8	0.0	0.4	0.0	0.4	0.0	0.3
Use within 5 years	90	1,772	21.1	34.9	34.4	32.7	31.1	20.5	11.1	8.1	1.1	2.3	0.0	0.5	0.1	0.3	0.0	0.1
Use by family member	67	1,539	16.4	35.2	38.8	34.6	31.3	18.6	11.9	8.2	1.5	2.5	0.0	0.5	0.0	0.0	0.2	0.1
Borrowing books	68	1,503	23.5	36.9	30.9	32.5	30.9	19.6	14.7	7.9	0.0	2.3	0.0	0.4	0.0	0.3	0.0	0.1
Reading in library	30	652	20.0	36.5	43.3	29.3	23.3	20.2	10.0	8.6	3.3	4.0	0.0	0.5	0.0	0.8	0.0	0.2
Specific research	49	977	26.5	33.7	38.8	33.2	22.4	20.5	12.2	8.7	0.0	3.3	0.0	0.3	0.0	0.3	0.0	0.1
School-related study	23	502	17.4	35.3	43.5	32.9	34.8	19.7	4.3	7.8	0.0	3.8	0.0	0.2	0.0	0.2	0.0	0.2
Work-related use	27	472	18.5	33.7	40.7	31.6	25.9	20.1	14.8	9.3	0.0	3.2	0.0	0.6	0.0	1.1	0.0	0.4
Use of A-V Material	21	390	19.0	32.9	38.1	33.9	33.3	22.1	4.8	6.3	0.0	3.3	0.0	0.6	0.0	0.5	4.8	0.5
Photocopying	38	717	21.1	32.9	28.9	31.2	36.8	24.4	13.2	7.3	0.0	3.3	0.0	0.5	0.0	0.1	0.0	0.1
All Respondents (Users & Non-users)	286	4,296	14.6	27.7	33.1	34.0	35.5	22.1	10.1	8.4	1.0	2.7	0.3	0.3	0.0	0.2	0.3	0.1

Wil. indicates the City of Wilmington
State indicates the State of Delaware

Taylor and Johnson, 1973) have noted a correlation between shopping and library use that is more pronounced as trip length increases. This factor is especially noticeable in rural areas (Chandler and Croteau, 1940; Cowing and Holtmann, 1976; Ramsay, 1958). Barton and Rector (1951) note a strong tendency for libraries in rural communities to be located in the heart of the central business district.

This association between shopping and library use has led to frequent advocacy of shopping center locations for libraries. *A National Plan for Public Library Service* (Joeckel and Winslow, 1948, p. 126) had this to say: "If a book can be picked up along with the day's groceries, it is likely to go into the shopping bag with the bread and butter." Many agree with Enser's (1950) opinion that the chief advantages of shop libraries are accessibility and the ability to draw non-conventional users (Brown, 1970). The Institute of Urban Life (1969), Frana (1976), Robinson (1976), and Yocum and Stocker (1970) all indicate the utility of retail site location techniques and market analysis for library site selection. Osborn (1971) analyzes the interaction between different pairs of community activities and concludes that libraries are commonly associated with shops, educational facilities and civic centers, in that order.

Mortimore et al. (1967) examined auto trips to libraries in England, Scotland, and Wales. They observed that hours of opening were significant to the extent that they matched patron's shopping habits. Thus, Saturday closures had little significance in market towns in Wales, where the traditional shopping day is Friday; but were highly significant in lowering patronage in England, where Saturday shopping is the rule.

Shopping center location may be an effective strategy in sparsely populated or highly mobile regions. However, experience with the more closely spaced branches of urban areas indicates that shopping is relatively less important as a correlate with library use for those living close to libraries.

Surveys spanning 30 years in Los Angeles (Cushman and Hayes, 1968; Hayes, 1979; Los Angeles, Bureau of Budget and Efficiency, 1949) show fewer than 10 percent of users combining library visits with shopping. Other urban surveys agree with this finding (Coughlin et al., 1972; Fouché, 1970; Shaughnessy, 1970). As a test of the shopping center attractiveness hypothesis, Janet Cochrane (1970) introduced a model which included retail floor space in nearby shopping centers as one of the variables associated with library use in London. Little correlation was observed. It should be noted that none of the libraries investigated were in the direct line of pedestrian traffic to the malls involved. Several were, in fact, nearly a mile away from the centers. Nevertheless, it would appear that shopping is not an essential correlate of library use in this particular study.

Community Awareness

A patron's perception of the distance to a facility may affect his/her willingness to travel more than the distance itself. Topological features such as ravines, rivers, major highways and other physical barriers, limitations imposed by youth or age, and cultural perceptions of "community boundaries" may affect attendance (Hubbard, 1978). Such influences may affect some segments of the population more than others.

Personal knowledge of the community has been studied in terms of shopping behavior (Cohen, 1973; Smith, 1976). Awareness of the environment is viewed as a function of cumulative exploration activities. An individual might reside in one location for three to five years before establishing firm shopping patterns. Library researchers (Nelson Associates, 1968; Woodsworth et al., 1975; Zweizig, 1973) have also noted an increase in attendance between the first and fifth year of residence.

Community awareness is a complex phenomenon. For the rural resident, a magnet-community may assume greater importance than the nearest village. Ramsay examines library patronage in rural Contra Costa County, California. She notes:

> In every case, the libraries which attract large portions of nonresidents are those located in centers which have a relatively high population density outside the mile radius and which, for a variety of reasons, exercise a strong drawing-power on readers who live more than a mile away (Ramsay, 1958, p. 122).

People are generally more aware of the traditional institutions in their surroundings; specifically "monolithic buildings with flagpoles" such as post offices, city halls, fire stations, police stations, and libraries (Lowrey, 1969). Benjamin (1974) and Zweizig (1973) associate the awareness of the library within the community with greater use.

Shopping, journey-to-work, and recreational habits also influence the individual's perception of "community." The geographic theory of spatial indifference (Hubbard, 1978) hypothesizes that a consumer of a service will perceive all similar facilities within his/her conceptual "home" territory as being equidistant. Getz (1980) notes that patrons in portions of New York City with numerous branches tend to shop among libraries for those with the most convenient hours, rather than patronizing the closest branch.

A study of library use in suburban Chicago (Institute of Urban Life, 1969) also indicates the probable existence of zones of patron indifference. The area studied is characterized by mobile citizens whose travel patterns cross traditional "community" boundaries. In such districts, concentration of library services at those branches most "visible" to the public may permit closure of less attractive facilities. The resultant reallocation of funds might

permit intensified service in the remaining branch, as manifested in longer hours of service, larger budgets for acquisition of new materials, development of community-specific programs, etc.

In other urban situations, the sense of community may at times become extremely localized (Martin, 1967). A dramatic example of this neighborhood effect is seen in the contrast between two "regional" libraries in Chicago (Schlipf, 1973). At one library, Hild, regional service is provided to a large part of Chicago's north side. At Legler, its sister library, less than a third as many books per capita are circulated and service is limited to the district. Patrons of Hild come from 22 of Chicago's 26 districts; Legler derives its clientele almost solely from its immediate neighborhood. Schlipf (1973, p. 277) describes the Legler vicinity as "a depressed area, both poverty-stricken and dangerous."

In such areas, residents live, shop, and visit libraries within the confines of their own territory, rarely venturing across invisible demarcation lines (Ley, 1974; Warner et al., 1973). If a single library branch serves a specific subgroup within an urban population, closure of that branch may effectively eliminate that group from the pool of library users, even though other branches may be physically accessible to patrons. Thus, it is important to study the spatial distribution of branches in relationship to the individual preferences of the user.

User Characteristics

The effects of economic and social characteristics of users on library use patterns have been documented on numerous occasions. On regional and national levels, studies range from the early work of Wilson (1938) to that of Williams (1980). Zweizig and Dervin (1977) and Evans (1979) summarize a number of individual use studies which appear in the published literature. These include works by Benjamin (1974), Bonser and Wentworth (1970), Campbell and Metzner (1950), Coughlin et al. (1972), Evans (1970), Knight and Nourse (1969), Kronus (1973), Monat (1967), Parker and Paisley (1966), Peil (1963), Taves (1965), and the University of the State of New York (1967). In the majority of these studies, distance is an important limiting factor on library use.

Williams (1980) identifies education, occupational prestige, and economic ability as the factors most correlated with library use among the variables studied. However, his study lacks an estimate of distance. Stratton (1976) and Young (1973) use similar statistical information, estimating distance as 2/3r, where r is the service radius of the average library. This formula has been proposed for economic models (Beckmann, 1968). Among the variables chosen for his regression analysis, distance is observed to be second only to bookstock in importance as a variable affecting circulation.

Below these rank the factors of population density, level of adult education, median income, per capita school enrollment, and percent of Blacks in the population. Young (1973) also notes the importance of expenditures and distance between libraries as major variables affecting use.

Arthur D. Little and John S. Bolles Associates (1970) compare the characteristics of branch and central library patrons using a method of correlation analysis. The composite descriptions obtained through their investigations are presented in Figure 3.

Kronus (1973) summarizes a number of patron surveys. She notes that age, education, occupation and income are found to be significant determinants of library use in more than 90 percent of the studies using these variables. By contrast, her examination of Illinois adults through regression and path analysis indicates that the commonly cited variables of age, sex, income, household head's occupation, and race have no independent effect upon frequency of library use. Major factors predicting library use in her study were those involved with education, stage of the life cycle, and urban residence. She hypothesized that "the greater accessibility of urban libraries may account for their greater use in contrast to small town libraries" (Kronus, 1973, p. 125).

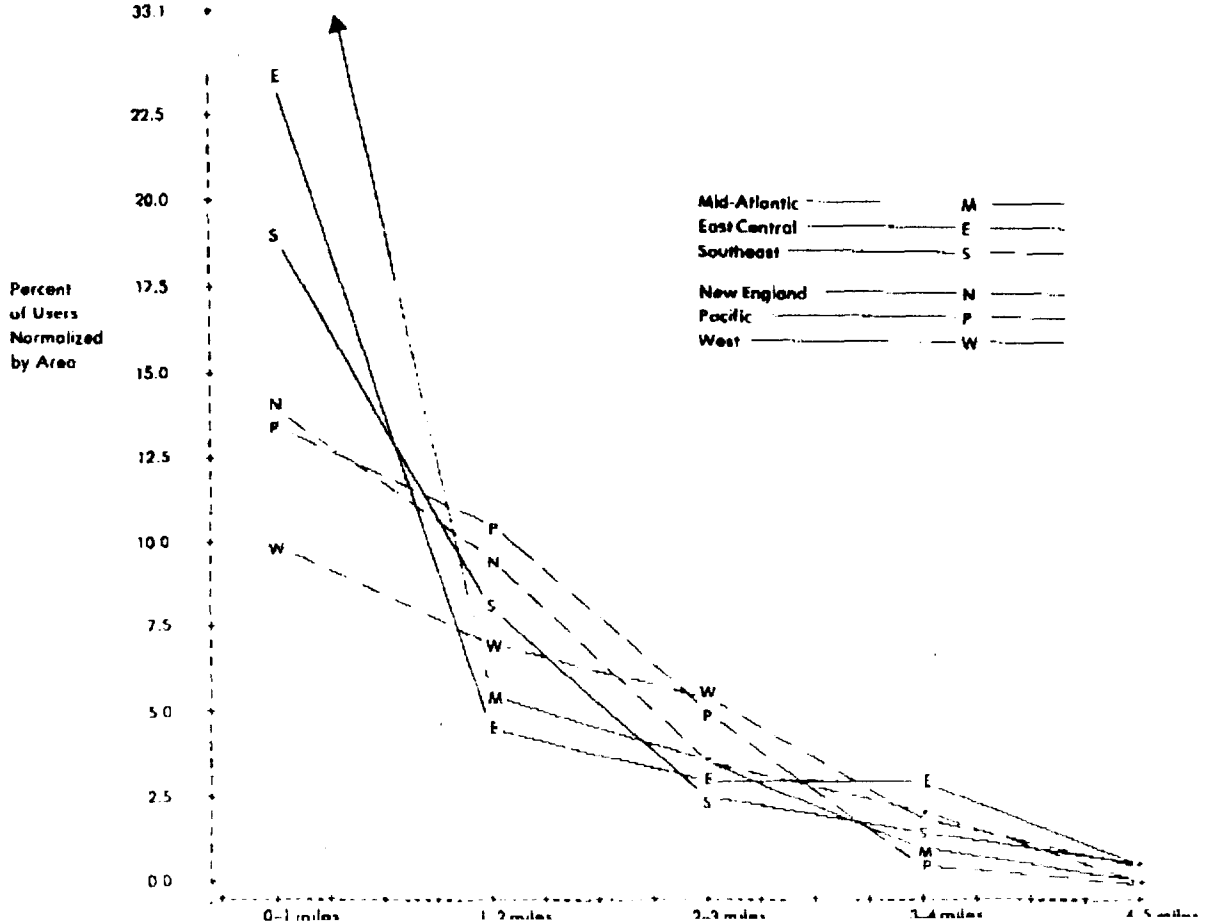
One of the most striking indications of the relative importance of distance with respect to other variables affecting library use is illustrated in the 1976 Gallup survey of attitudes toward the public library (Gallup, 1976). For this survey, respondents were asked to indicate the distance from their residence to their most frequently used public library. Their answers have been cross-tabulated by age, sex, education, occupation, readership level, stage in lifestyle, and region of the United States. The Gallup Survey concurs with Kronus in the identification of education, and stage of life cycle as significant factors in library use. More significant than these variables, however, are the degree of urbanization, as indicated by region of the United States, and the level of intensity of library use. Figure 4 demonstrates regional differences graphically.

Two basic usage patterns are discernable. The first applies to regions of fairly high regional density and to established urban areas such as the Mid-Atlantic States, the Eastern Central Region, and, to a lesser extent, the Southeast. User response in the "megalopolis" of the Mid-Atlantic States may be viewed as a paradigm for the usage pattern prevalent in these regions.

Nearly one-third of users in the Mid-Atlantic States preferentially attend libraries within a mile of their home. This represents an increment of 10 percent over the national average. The increment may be due to the relatively closer spacing of libraries in this urban-suburban region, since this permits service to more patrons with moderate or light motivation toward library use.

	San Francisco Main Library			San Francisco Branch Libraries		
	walking	car-taxi	bus	walking	car-taxi	bus
origin		home	school			school
age	41–60 years and retired	20–40 years	13–25 years	18 or younger and students	26–60 years	
occupation	sales clerical	professional	student	students	housewives professionals	
travel time	6–10 minutes	11–15 minutes	16–30 minutes			
purpose		professional use, occupationally oriented books	homework	homework	personal use	

Figure 3. Correlation Between Mode of Transport and Selected User Characteristics
(Arthur D. Little, Inc., and John S. Bolles Associates, 1970, pp. 70, 71)



Patron response to distance presents a different pattern for New England and the Western regions. For the most part, these areas are characterized by low population density and concentration of library services in market towns. The percentage of use within the first mile is significantly lower than the national average (Table II). This usage pattern might be expected since patrons with high motivation toward library use comprise the bulk of the readership. The trip to the library, as long as it falls within his/her zone of indifference, would have little detrimental effect on attendance.

Library Spacing

It would appear from the studies cited in Table I that the zone of indifference within which library patrons travel freely rarely exceeds four miles. The uniformly low level of patronage beyond this limit is consistent with Hodgson's (1946) and Schuler and Turbeville's (1948) hypotheses concerning a core population of library users with highly inelastic demands.

The spatial limitations of library patrons have important implications for library planners. Communities whose citizens are actively interested in the public library may expect a fair degree of patronage within a 2-to-3-mile service area. Location of the library near a concentration of potential users within this general area may serve to supplement regular patronage with additional walk-in users. Demographic studies and utilization of urban planning will assist in the identification of potentially favorable areas. Within these areas, sites with superior drawing potential may be identified using principles such as those outlined by Galvin (1976).

Proper location of a new library branch within a suburban community presents a challenge for the site selection committee of a library system. Decisions concerning extant branches in heavily populated regions may also involve complex deliberation. Older branches in the inner city may require extra funds for maintenance and protection from vandalism (Schlipf, 1973). Staffing of a number of branches which serve overlapping districts may be viewed as a wasteful expenditure (Cuyahoga County, Ohio, Regional Planning Commission, 1966). Getz (1980) offers a particularly strong case for urban branch closure. He notes that recent budget cuts have caused severe restrictions on the hours of service within the New York Public Library System. Hence, branches physically accessible in terms of location become inaccessible to patrons in terms of hours open. Getz recommends closure of some branches in order to increase funds available throughout the system.

The decision to consolidate branches within a portion of a library system involves a careful review of the use patterns within the district. Areas such as the Chicago North Shore, where relatively mobile patrons favor libraries along main arteries, may be amenable to closure of less visible branches (Institute of Urban Life, 1969). Branches which sustain high levels

of in-house use by patrons from the immediate vicinity may provide im tant services to their neighborhoods which would be forfeited were th close.

Some segments of the population are particularly associated with h in-house use patterns. Among these are students and elderly citizens. dent use of reading rooms to study school texts rather than library mate is a frequently observed phenomenon (Haas, 1962; Cuyahoga County F ning Commission, 1966; Martin, 1963). Johnstone et al. (1977), in an ir view of residents in urban Hispanic neighborhoods, found frequent men of library use by students as a means of escaping a crowded, noisy h environment. Elkin (1972) defines a need for "private space," especially those in urban environments. When a library is conveniently located, eld patrons frequently use it daily, indicating that libraries may serve a sc function as well (Healy et al., 1980).

Identification of a branch with a particular segment of the commu may also be cause to advise against closure. Getz (1980) notes widespr resistance among patrons of the New York Public Library (NYPL) sys to closure of neighborhood branches. On a more general scale, Savas (19 p. 803) observes:

> With governments under pressure to assure that public services do not discriminate against any particular group of citizens, they must be concerned with the distribution of inputs, outputs, and effectiveness among their service recipients. Because many cities have neighborhoods that are populated predominantly by people who share a common characteristic, such as race, ethnicity, religion, income, or age, it is necessary to explore the implications of different seemingly equitable formulas for the spatial distribution of services.

Beyond the legal obligation to equal service lies the moral comm ment of public libraries to the principle of social betterment. Lowell Mar (1979, p. 292) champions the cause of progressive library policies with p ticular vigor:

> There are both social and tactical reasons for reaching a wider segment of the people while retaining present strength and clientele... Reasonable concern for the many others, who are "information poor," would prompt efforts to open this source to them, and if necessary to redesign collecting and distribution policies in order to share the knowledge wealth. This is not a matter of information welfare, a hand-out to a small subclass, but a matter of import to a broad part of the spectrum...

Equity

Fulfillment of legal obligations toward equal provision of public servi may be accomplished in a variety of ways. Each "equitable" decisi favors some groups while putting others at a disadvantage. Savas (197

details the implications of several different "equitable" solutions to distribution of public services. These can be applied readily to the library situation:

> Equal Payment:
>
> For tax-supported services, it is generally difficult to establish the proportional contribution of a specific individual in relation to the total institutional budget.
>
> Equal Payment for Equal Amounts of Service:
>
> Specific services may be paid for by the unit. For example, photocopying machines within the library require specific payments per unit. However, equality by one measure may be construed as inequality by another. As an illustration, an annual nonresident user fee is equitable in that it charges the same rate for all patrons. However, the individual who checks out one book pays a much higher per-unit price for this service than the patron who checks out a number of books over the course of a year.
>
> Equal Output:
>
> Services may be distributed such that equal results are achieved in each subarea. This results in unequal inputs since some users may have to travel further than others. In addition, it may be difficult to establish measures which can adequately equate services between different branches. One library may give a high degree of walk-in service while demonstrating lower-than-average circulation as an example.
>
> Equal inputs:
>
> Systems may provide equal investment in facilities. Complexities arise since "equality" can be interpreted in several ways:
>
> a. Equal inputs per district. This allocates equal numbers of service units per neighborhood. Community pressures may favor this approach. However, when population density varies, service may not be equal.
> b. Equal inputs per unit area. This spaces facilities evenly throughout an area, but doesn't allow for differences in population density.
> c. Equal satisfaction of demand. Demand can be determined by a measure of use (such as circulation), a unit of complaint (neighborhood action groups, etc.), or a weighted unit of complaint (political display of interest). All of these measures favor the active, vocal consumer.

Morrill (1974) adds an additional "equitable" approach. His minimax solution requires that the maximum distance travelled by those on the periphery of an area be minimized.

The plethora of means to achieve quality emphasizes the importance of the decision process in the final resolution of any site selection program.

V. PUBLIC FACILITY LOCATION THEORY

The discussion to this point has focussed specifically on the relationsh the user to the public library. The social, economic, and behavioral ch teristics which have been detailed here, with respect to this particular tution, present, in a microcosm, more generalized patterns of s behavior in the social environment. Likewise, the problems which the p library must address in response to the user's spatial behavior are indic of problems facing many public institutions. Thus, the library planner benefit from an understanding of generalized decision models develope a wide range of public facilities. A brief overview of the types of m which have been developed to respond to a public facility location pro will be presented in this section. Specific applications to the library situ will be noted.

Central Place Theory

One means of envisioning the distribution of a service in the urban env ment is to postulate a system with one centrally located master facility a latticework of equally spaced satellites (Christaller, 1966). Models are structed to apportion a fair percentage of goods to each member o heirarchy established (Dökmeci, 1979; Nijkamp, 1976).

A first approach to this concept in library literature may be seen i works of Brookes (1970) and Stanfel (1979). Brookes hypothesizes tha main library will have a collection sufficient to fulfill all user needs, v the branch will supply only a fraction of user requests. The rational user consider the nature of his/her requirements, and determine the probab of a specific book being held at the branch. If the probability is high tha branch will suffice, the patron will travel to the branch since the cost of taining the book in terms of time and money will be less. Conversely, sh will go directly to the main library if the probability of success at the br is small. The size of the collection at the branch, then, will be calculate that proportion of the main collection which will satisfy the user's needs quently enough to warrant the exploratory trip to the branch. If the pa is disappointed with branch services too frequently, she/he will bypass branch and patronize only the main library. Stanfel (1979) enlarges u this hypothesis by considering the cost of supply for the library as we the cost of travel for the patron.

This type of model assumes fixed numbers and locations of branc The size of the collection becomes the variable. Public facilities' loca models after Teitz (1967) allow the distance and size of the branches in a work to vary within a fixed budget. Several models which may apply to

library situation have been proposed. They will be considered in the following sections.

Distributed Goods

A number of public facilities models are based on the assumption that services are to be distributed equally to all members of a community. These are frequently referred to as "covering" solutions to the facility problem, since the goal is to space facilities at equidistant locations, assuring equal coverage for all points within a district. White and Case (1974) review a variety of models which use this approach. Older "rules of thumb" such as the 1-mile service radius concept for public libraries represent application of a covering approach.

Newer covering models for public libraries may utilize computerized techniques. Public Technology (1978) has designed a computerized package which calculates travel time between portions of a city, and identifies locations which will permit delivery of services to all points of a city within specified times. Such programs are particularly important in the location of emergency services, such as ambulance stations. A library model has been proposed along the same lines (Public Technology, 1974). Kochen (1976) also discusses a travel-time minimizing model. Robertson (1972) utilizes statistical packages developed by the British government to define library catchment areas in terms of population density.

Travelled-for Goods

A basic problem with the use of distributed goods models is that they assume the service will be equally available to everyone. Some services, such as the transmission of radio waves or disposal of sewage, approach this ideal. However, other public facilities such as museums, parks, libraries, and hospitals are organized on the implicit assumption that the patron will provide his/her own transportation to the site (Lea, 1979). Consumption of such services is inherently unequal, since some patrons must invest more time and energy to attain the goods than others. Patron resistance to travel becomes an important limiting factor in models for travelled-for goods, since a facility will fail to serve patrons beyond certain perceived limits.

ReVelle and Church (1977) suggest a model for the location of public libraries which incorporates a measure of user resistance to travel. Library size is defined as volumes in a collection. A budgetary restraint is imposed; equations are solved to determine the size and optimal number of facilities to cover an area within the limits of patron travel behavior.

A model such as that of ReVelle and Church is theoretically sound. In practice, it may be difficult to apply, since few public service institutions have the opportunity to start from scratch and place branches at optimal locations (Hodgart, 1978).

Gravity Models

A group of models which are well adapted to the addition of a facility to a group of existing branches (Bach, 1980) are known by the general term of gravity models, after Reilly's (1931) analogy between shopping behavior, and the attraction between heavenly bodies. Roberts (1966) applied a basic shopping center location gravity model to assist in site selection for a public library in Scunthorpe, England.

One of the most widely used gravity models is that proposed by Huff (1962) and first developed by Lakshmanan and Hansen, (1965). This Market Potential Model compares a shopper's probability of using a store in one district with that of his/her using a market in competing districts. Getz (1980) makes use of this model when he compares library users' responses to a group of libraries which differ in the hours of service they offer their patrons. He introduces an intervening opportunity element which allows comparison of competing services that vary in attractiveness to the patron.

In gravity models, "attractiveness" is generally defined in terms of floor space. Shaughnessy (1970) used floor space as one of his variables to describe library service in three states: New York, Pennsylvania, and New Jersey. He observed that such a measure was considerably less significant in describing library use than four other factors in his regression analyses: (1) volumes, (2) budget, (3) professional staff, and (4) number of seats available. As previously mentioned, other suitable measures might include hours open, new acquisitions, circulation, registration, reference questions asked, or attendance.

Gravity models normally include a factor representing varying consumer response to a given service. They usually define this in terms of income, since spending power reflects the ability of a consumer to utilize a store. Since income and library use are frequently positively correlated, such a factor could be used effectively in library studies. However, Evans (1979) points out that surveys requesting estimates of library patron income levels may offend some patrons. Since this factor is closely related to education (Kronus, 1973), the level of educational achievement may be a more useful practical measure in library studies.

Elastic Demand Models

Abernathy and Hershey (1972) provide the conceptually intriguing approach of presenting an equation which may be optimized in several different ways. The possibilities afforded include these optimizations:

1. Maximize utilization:
   This favors those with low mobility, if use is otherwise equal, since